A New Species of *Limnadia* (Crustacea: Conchostraca) from the Granite Belt in Southern Queensland and Northern New South Wales

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Eulimnadia is synonymized with *Limnadia*, as the character separating the two, the presence or absence of a spine on the lower distal angle of the telson, is gradational and therefore unsatisfactory. *Limnadia urukhai* sp. nov. is distinguished from other species of the genus by the evenly curved dorsal margin and moderate size of its carapace (up to 6.7 mm by 4.3 mm), its few growth lines (maximum 10), small number of pairs of legs (15-16), two almost equal segments of the sixth endite in the first pair of claspers, and lack of a spine on the lower distal angle of the telson. On the basis of the variability noted in some morphological characters both by previous workers and in the present study, the Australian species *Limnadia cygnorum* and *L. rivolensis* may be synonymous.

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INTRODUCTION

The Queensland conchostracan fauna has been little studied; of the 23 previously known Australian species, only 3 have been recorded from Queensland. These are *Limnadia rivolensis* (Brady 1886) and *Caenestheria berneyi* (Gurney 1927) from the Longreach district (Gurney, 1927), and *Cyclestheria hislopi* (Baird 1859) from Rockhampton (Sars, 1887). In addition, in the Queensland Museum there are specimens from Stradbroke Island provisionally identified as *Lynceus* cf. *tatei* (Brady 1886), and from Cunnamulla labelled *Cyzicus* cf. *dictyon* (Spencer and Hall 1896).

Thus it is of considerable interest that several populations of conchostracans collected from small rainwater pools in the Granite Belt of southern Queensland and northern New South Wales proved on close examination to be a new species of *Limnadia*.

Genus *Limnadia* Brongniart

Limnadia Brongniart 1820, p.84; Daday 1925, p.147; Ueno 1927, p.281; Brehm 1933, p.31; Straskraba 1965a, p.263.

Eulimnadia Packard 1874, p.55; Sars 1895, p.14; Daday 1926, p.1; Barnard 1929, p.251; Mattox 1954, p.6.

Paralimnadia Sars 1896, p.15; Daday 1925, p.146.

Type Species. Limnadia lenticularis (Linnaeus 1761).

Diagnosis. Umbo lacking, lines of growth restricted to marginal portion of shell (i.e. large larval valve), dorsal margin smooth; frontal organ on top of pyriform appendage; first antennae long, unsegmented (after Straskraba, 1965a).

Discussion. The differences between *Limnadia* and *Eulimnadia* have been treated differently by different authors. Packard (1874) erected *Eulimnadia* for species that were distinguished from those in *Limnadia* by having a narrower shell with a straighter dorsal margin, fewer lines of growth, larger gills, shorter flabellae, and fewer pairs of legs. But, as Sars (1895) and Straskraba (1965a) pointed out, the size and shape of the shell and the number of growth lines can be very unreliable characters; they are closely related to environmental conditions and the age of the individual (Massal, 1954), and often cannot be used to differentiate between species. The validity of using the size of the gills has been questioned by Brehm (1933) and Daday (1925), who felt that this feature also could be strongly altered by external conditions. The flabellum length varies considerably between species, from shorter than to nearly twice as long as the leg to which it is attached. The number of pairs of legs shows a similar variability from 16 to 26.

For these reasons Sars (1895) questioned the validity of *Eulimnadia,* although he considered that one feature could definitely be used to separate the 2 genera: no males were known for any species of *Limnadia.* Daday (1925) and Barnard (1929) thought this an insufficient criterion, as although only females have been recorded for several limnadiid species, in most cases this is probably due to the small number of specimens collected (*L. lenticularis* is an exception). Daday instead proposed a single morphological distinction: the presence (*Eulimnadia*) or absence (*Limnadia*) of a spine on the lower distal angle of the telson. Since there is a complete gradation between these two extremes (Fig. 1), this character is somewhat unsatisfactory, as Barnard (1929), Straskraba (1965a) and even Daday (1925) have noted. Daday (1925) felt that *Eulimnadia* and *Limnadia* should be subgenera but retained them as genera for "historical and practical reasons".

Ueno (1927) adopted the position that species with numerous growth lines and 12-13 segments in the flagellae of the second antennae should be *Limnadia,* whereas those with 4-6 growth lines and 9-10 antennae segments would be referred to *Eulimnadia.* However, Brehm (1933) found that the subdivisions in the second antennae were indistinct, difficult to count, and could vary from 8 to 12 in one individual.

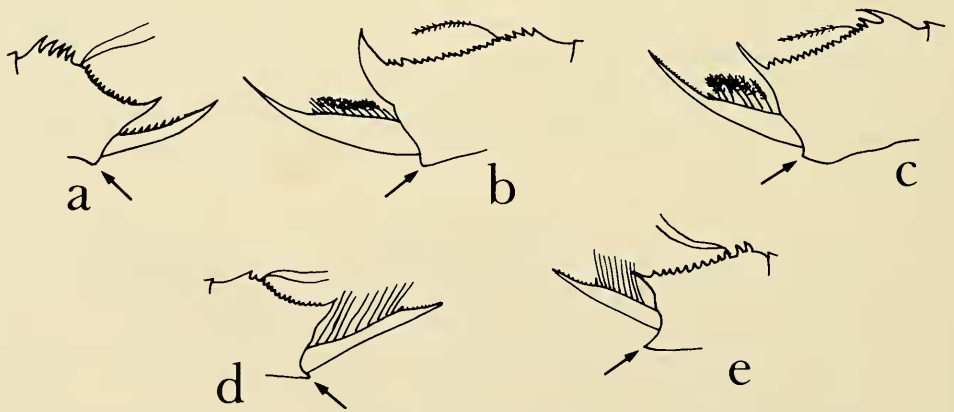


Fig. 1. Telsons of (a) *Limnadia lenticularis* (Linnaeus 1761), (b) *L. rivolensis* (Brady 1886), (c) *L. victoriensis* (Sayce 1903), (d) *L. texana* (Packard 1874), and (e) *L. similis* (Sars 1900), showing variation in shape of lower distal angle (indicated by arrows). From Daday (1925), Straskraba (1965a), Sayce (1903), and Daday (1926).

Mattox (1954) reaffirmed that the number of pairs of legs, the shape of the lower distal angle of the telson, and the number of segments in the second antennae could be used to separate *Eulimnadia* from *Limnadia*.

Some species can be assigned to either genus, depending which of the above criteria are used. *L. urukhai* sp. nov. would be referred to *Limnadia* on the basis of its telson shape, but the presence of males, and the small number of pairs of legs (15-16) and antennae segments (8-10) would place it in *Eulimnadia*. Most authors have relied entirely on the outline of the lower distal angle of the telson. Although this appears to show little variability within species, the gradation illustrated by Fig. 1 indicates that it is not a satisfactory character for distinguishing genera. Therefore *Eulimnadia* should be synonymized with *Limnadia*.

Sars (1896) differentiated *Paralimnadia* from *Limnadia* on the almost straight dorsal margin in the male carapace of the former, its large number of growth lines (up to 30), and relatively small larval valve (as little as 25% of overall valve length). However, the dorsal margin and larval valve of the female shell are only slightly different from those of many other limnadiid species, some of which have more growth lines. Daday (1925) synonymized the 2 genera and this is followed here.

Distribution. World-wide.

Limnadia urukhai, sp. nov.
(Figs 2-25)

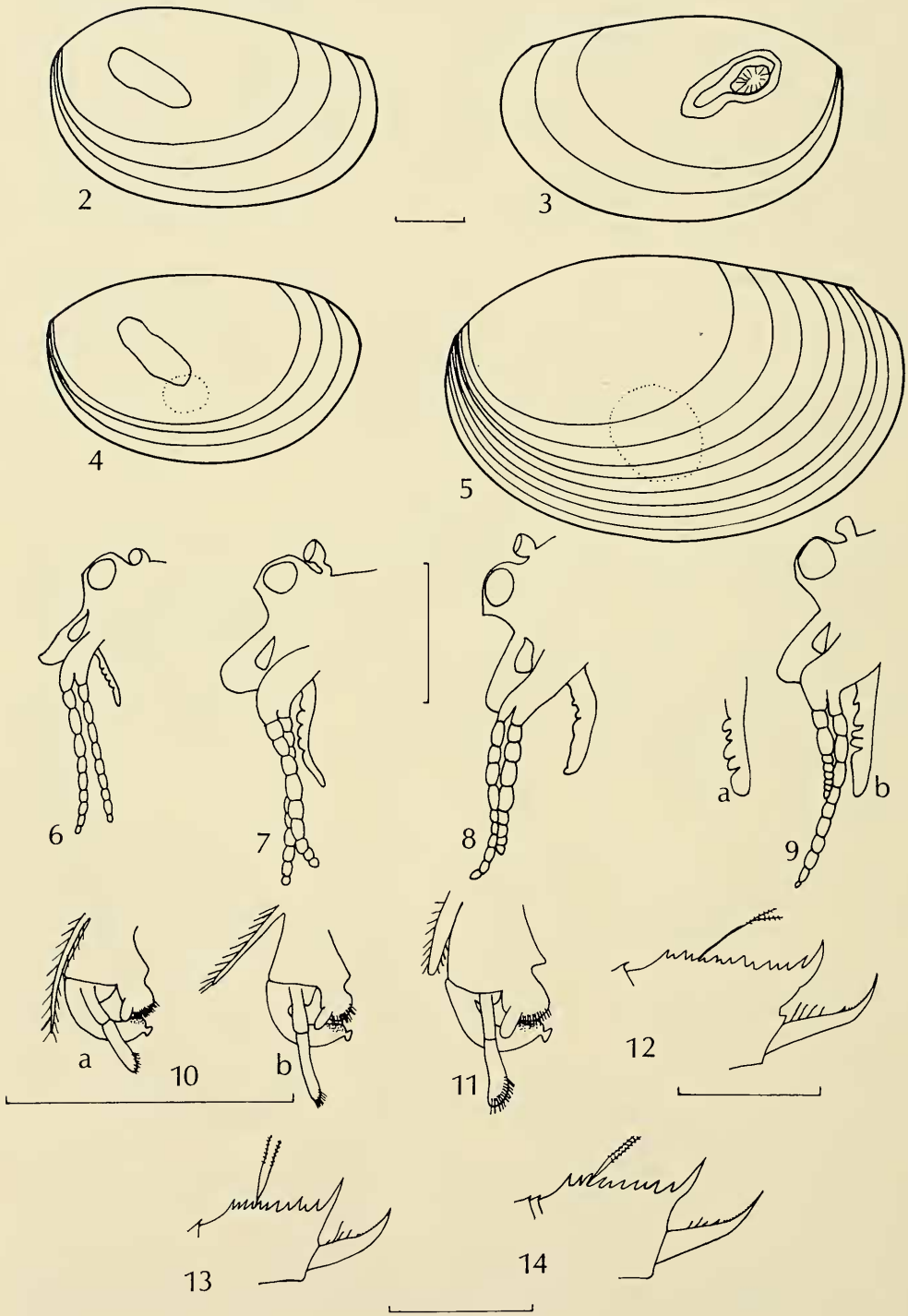
Types. Queensland: Sow and Pigs, near Stanthorpe, 26.iii. 1978, G. Bell, 1 ♂ (holotype, W7499), 5 ♂, 9♀ (W7500); Mt. Norman, near Stanthorpe, 9.iv. 1978, J. Surridge, 10 ♂, 19 ♀, 4 juveniles (W7502); Stanthorpe, Nov. 1929, H. Jarvis, 4 ♂, 2♀ (W268). New South Wales: Bald Rock, near Tenterfield, 26.iii. 1978, A. Ewart, 7 ♂, 1♀ (carapaces only) (W7501). All specimens housed in the Queensland Museum.

Diagnosis. Bisexual; male and female carapaces similar, with evenly curved dorsal margins, large larval valves, and up to 10 growth lines, maximum size 6.7 mm by 4.3 mm; 15-16 pairs of legs; 2 segments in sixth endite on first pair of claspers almost equal in length; no spine on lower distal angle of telson.

Male. Dorsal margin of carapace always smoothly curved (Figs 2-5); antero-dorsal and postero-dorsal corners usually obtuse and angular (Fig. 3), but occasionally rounded (Figs 2, 4); rarely slight concavity ventral to postero-dorsal angle (Fig. 5). Maximum carapace measurements 6.7 mm by 4.3 mm, with 10 growth lines present. Larval valve constitutes as little as 55% of overall carapace length. Elliptical shell gland (or muscle scar) always contained entirely within larval valve, and greatest dimension 20-35% of overall carapace length.

Colour of carapace varies during ontogeny: juveniles with no growth lines transparent; adults dark brown on larval valve with yellowish growth segments, and clear spot close to ventral margin of larval valve (Fig. 4, dotted circle), forming "window" through which claspers often visible. With increase in number of growth segments, clear spot increases in size and shifts ventrally (Fig. 5). Micro-ornament of shell very subdued punctate, although ridges between punctae sometimes reticulate, rarely showing indistinct radiating pattern.

Basal stalk of pyriform appendage undifferentiated in immature individuals (Fig. 6); normally very short in adults (Figs 8, 9), occasionally long (Fig. 7). Eye lobe (prominence carrying paired eyes) close or immediately adjacent to frontal organ; angular projection on anterior side usually noticeable (Figs 6-8), occasionally very small and indistinct (Fig. 9b). Occipital notch commonly right-angled although obtuse in immature specimens (Fig. 6). Ocellus elongate triangular to tear-drop in shape, rarely sub-elliptical. Rostrum extends beyond ocellus for approximately length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of ocellus, with well-rounded termination, rarely pointed in immature individuals (Fig. 6).

First antennae long, reaching second, third or fourth segment of second antennae, with 3 to 6 non-setose papillae on anterior side, Size and distinctness of papillae vary considerably, even within one individual (Figs 9a, b).

Scape of second antenna extends slightly beyond rostrum; each flagella has 7 to 10 segments, often poorly differentiated towards tip and difficult to count. Flagellae normally almost equal in length, rarely one only half as long as the other (Fig. 9b).

Fifteen to 16 pairs of legs, first 2 modified as claspers. Third endite of claspers varies in length, and projection below fourth endite (thumb) often indistinct (Fig. 10a). Sixth endite (subapical appendage) in first pair of claspers bipartite, apical segment slightly longer than basal (Figs 10a, 11). Tip carries short setae, but none at joint between segments. Apical segment of sixth endite in second pair of claspers much longer than basal (Fig. 10b), otherwise the two pairs of claspers similar.

Posterior 8 to 12 abdominal segments typically with 1 to 2 dorsal spines, but occasionally middle 5-8 segments each have up to 8 dorsal setae.

Dorsal margin of telson armed with 10 to 15 spines; posterior spine longest and straight, curved, or protruding beyond posterior margin of telson (Figs 12-14). Other dorsal spines vary irregularly in size, even between two halves of telson of one individual. Forked filament between third and fifth spines from anterior end. Caudal claws as long as or slightly shorter than dorsal margin of telson, with few small setae and usually one small spine on dorsal surface. Lower distal angle of telson right-angled or slightly obtuse, and corner angular or slightly rounded.

Female. Female carapace occasionally with more arched dorsal margin (Fig. 16) and smaller dimensions (maximum 6.2 mm by 4.1 mm) than male; otherwise very similar (Fig. 15), except lacks clear spot mentioned previously.

Female head (Figs 17, 18) resembles that of male except occipital notch obtuse and rounded, becoming less obtuse in older specimens. Rostrum extends short distance past ocellus, termination rounded and right-angled.

First antennae extend only to first or second segments of second antennae, and have 2 to 3 poorly differentiated papillae (Fig. 18), or occasionally up to 5 well-marked papillae (Fig. 17).

Second antennae, number of pairs of legs and dorsal modifications of abdominal segments same as for male.

Ninth and tenth legs each possess long narrow flabellum (Fig. 19), up to 1.5 times as long as leg.

Posterior spine on dorsal margin of telson generally protrudes beyond and inclined to posterior margin (Figs 20, 21); this is less common in males.

Eggs 0.14 to 0.20 mm in diameter, covered with irregular or semi-regular pattern of ridges (Figs 25 a-c). Largest clutch carried by any female about 80.

Juvenile. Shell of smallest individual collected transparent with no growth lines, measuring 2.3 mm by 1.3 mm; dorsal margin only slightly curved (Fig. 22). At least 12 pairs of legs differentiated (posterior legs difficult to count), 6 to 7 segments in flagella of second antennae, and 9 spines on dorsal margin of telson (Fig. 24). No

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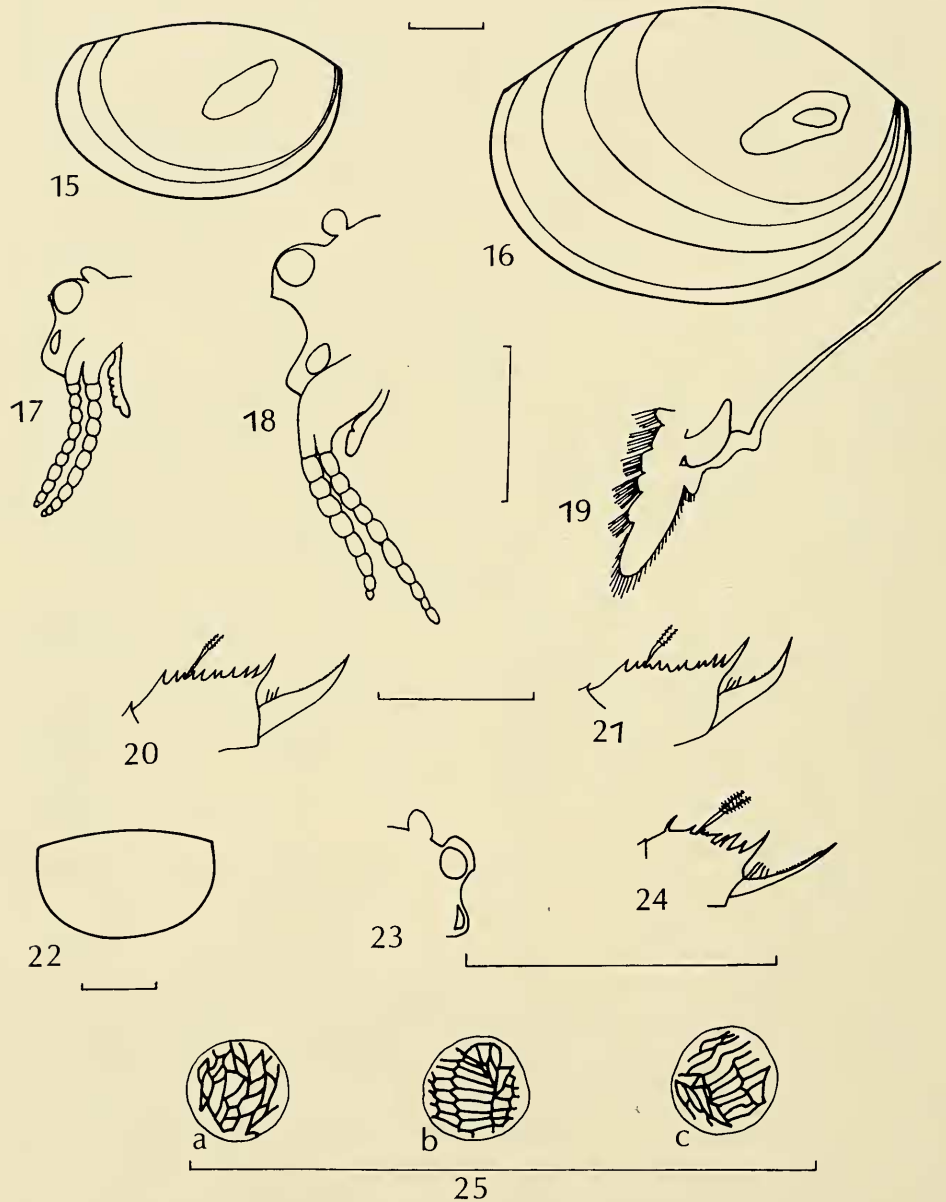
Figs 2-14. 2. Carapace (♂), W7502. 3. Carapace (♂), W7499 (holotype). 4. Carapace (♂), W7502, showing clear spot (dotted circle). 5. Carapace (♂), W7501, showing clear spot. 6. Head (♂), W7502. 7. Head (♂), W7500. 8. Head (♂), W7499 (holotype). 9a, b. Head (♂) W7500, showing both first antennae. 10a, b. First and second claspers, respectively, W7502. 11. First clasper, W7499 (holotype). 12. Telson (♂), W268. 13. Telson (♂), W7500. 14. Telson (♂), W7499 (holotype).
All scale lines represent 1 mm. For the sake of clarity, setae at joints between segments of second antennae have been omitted.



Figs 15-25. 15. Carapace (♀), W7502. 16. Carapace (♀), W7500. 17. Head (♀), W7502. 18. Head (♀), W7500. 19. Flabellum, W7502. 20. Telson (♀), W7500. 21. Telson (♀), W268. 22. Carapace (juvenile), W7502. 23. Head (juvenile), W7502. 24. Telson (juvenile), W7502. 25a-c. Eggs, showing pattern of surface ridges.
All scale lines represent 1 mm. For the sake of clarity, setae at joints between segments of second antennae have been omitted.

flabellae, claspers, or eggs developed. Frontal organ well differentiated, although pyriform appendage lacks basal stalk (Fig. 23).

On slightly larger specimen, still with no growth lines, 15 pairs of legs visible while other features the same. With one growth line, number of segments in second antennae 7 to 10. In specimens with 2 growth segments dorsal margin more curved, 12 dorsal spines on telson, pyriform appendage has basal stalk, and flabellae present in females. These specimens have adult complement of legs, second antennae segments, and telson spines. Individuals with 3 growth lines show claspers or eggs, indicating full sexual maturity. The previous descriptions of males and females were based on such specimens.

Ontogenetic variation in some characters can still occur after the onset of sexual maturity, as indicated already for the occipital notch in both sexes and the rostrum in males.

Discussion. Limnadia urukhai differs from species previously assigned to *Eulimnadia* in its lack of a spine on the lower distal angle of the telson. With regard to the other species of *Limnadia,* it is readily differentiated from *L. stanleyana* King 1855, since in the latter the male carapace has an almost straight dorsal margin, whereas that of the female is strongly curved; furthermore the larval valve of *L. stanleyana* constitutes as little as 20% of the overall shell length. *L. grobbeni* Daday 1925 and *L. wolterecki* Brehm 1933 are both very large, reaching 19 by 13 mm and 22.3 by 16.6 mm respectively, with up to 45 growth lines. The dorsal margin in both species displays a slight concavity absent in *L. urukhai.*

L. urukhai can be distinguished from the three Australian species *L. cygnorum* (Dakin 1914), *L. rivolensis,* and *L. badia* (Wolf 1911) by its smaller number of legs (15-16 as against 18-20), and by the two almost equal segments of the sixth endite of its first clasper, where the other species have the apical segment twice as long as the basal or have 3 segments. *L. lenticularis* differs in that no males of this species have ever been described (despite extensive collections), the female rostrum is very acute, and there are 22-24 abdominal segments.

The work of several previous authors, notably Straskraba (1965a), demonstrated that intraspecific variation in some characters is considerable, and the present study has enlarged on this. Putting this information together reveals that the following characters are not taxonomically useful for limnadiids: presence of angular projection on eye lobe, ocellus shape, number and distinctness of papillae on first antennae (particularly in females), relative lengths of flagella of second antennae, dorsal modifications of abdominal segments, presence of small spine halfway along caudal claw, and inclination of posterior spine on dorsal margin of telson to that margin. In addition, Brehm (1933) found that the number of segments in the flagella of the second antennae can range from 8 to 12 in one individual, and illustrations in Daday (1926) and Barnard (1929) show that setae at the joints of the sixth endite of the claspers may be absent or present. Figures in Sars (1895) reveal that in *L. stanleyana* the surface of eggs varies from ridged to subdued spinose, and Dakin (1914) found that the shell gland may or may not be confined to the larval valve.

The following characters, although they show considerable variation, are thought to be useful if treated cautiously: prominence of projection below thumb of clasper, shape of rostrum and occipital notch, length of first antennae, number and relative lengths of joints of sixth endite of first clasper, number of pairs of legs, number of dorsal spines on telson, number of setae on caudal claw, shape of lower distal angle of telson, shape of dorsal margin and maximum dimensions and number of growth lines of carapace, and relative sizes of larval valve and shell gland. Ontogenetic variation in any of these must be taken into account.

TABLE 1

Differences between *Limnadia cygnorum* and *L. rivolensis*

	L. cygnorum	*L. rivolensis*
frontal organ	slightly elongated	normal
number of pairs of legs	18	20
spine halfway along caudal claw	absent	present
projection below thumb of clasper	prominent	moderately well-marked
number and relative lengths of segments in sixth endite of first clasper	2, apical one twice as long as basal	3, subequal
surface of eggs	subdued spinose	spinose

Of the other characters, the following may be important but too little is known of their variability: size and shape of frontal organ, length of flabellae, presence of setae on first antennae, and colour and micro-ornament of shell.

Among the 24 Australian conchostracan species there are probably several synonymies, as suggested by Williams (1968) ; detailed studies of European and North American faunas have considerably reduced the number of species there (Straskraba, 1965 a, b, 1966; Sissom, 1968; Wiltshire, 1974). Applying the above knowledge of character variability to the Australian limnadiids reveals that *L. cygnorum* and *L. rivolensis* may be synonymous, as intimated by Glauert (1924). Table 1 lists the differences between them; the only significant one refers to the sixth endite of the first clasper. If the apical segment in *L. cygnorum* is in fact divided in half, a possibility admitted by Dakin (1914) in his original description, then the differences separating the species are within the limits of intraspecific variation and they are synonymous. A final decision must await re-examination of the original specimens, as the published descriptions omit certain features.

Distribution. Probably throughout the Granite Belt of southern Qld., extending into at least the northern portion of the New England Tableland in N.S.W.

Ecological notes. The specimens of *L. urukhai* collected occurred in small (1 to 2m² area) shallow (4 to 5 cm deep) rainwater pools on bare granite outcrops. However, only the larger of these pools were occupied by conchostracans, in association with slugs and chironomiid insect larvae. The insect larvae appear to eat the soft parts of dead conchostracans, such that dead individuals left overnight had only their shells remaining in the morning. One population of *L. urukhai* on Mt. Norman was bright green due to a heavy infestation of algae, particularly on the legs. This was identified as *Characium* spp. by Dr A. B. Cribb, Dept. Botany, University of Qld. In some pools there were large numbers of individuals, many vigorously copulating. *L. urukhai* is an active species; it generally swims with the long dimension of the shell at about 45° to the horizontal and its head upwards, but can adopt any other position. At the surface it turns upside down and moves along venter upwards. When frightened or resting it buries itself sideways or venter upwards in the bottom sediment. Many specimens were observed feeding in the algae on the pool bottoms.

Specimens at the Sow and Pigs were believed to be about 9 days old when collected, since the only rain for several months had fallen 10 days previously. They survived for 3 days after collection, when they had a maximum of 4 growth segments.

Relative proportions of males and females varied considerably in different collections, females making up 30% to 85% of the specimens.

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